**Modernization of Biomass for Poverty Reduction**
**Background Paper**
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# 1 Purpose and Orientation

**1.1** The purpose of this note is to provide the background and context for the first Electronic Dialogue of the Shell Foundation's Sustainable Energy Programme (for further details see www.shellfoundation.org). This document poses a number of questions and takes a number of positions. However the dialogues will be conducted by asking you to address four specific questions posted each week of the dialogue. The contributions will be summarised each week and sent to participants along with the next question. We will then convene a small workshop to define the precise form of the Shell Foundation's strategy in this area. These will be publicised at the end of June, and we advise you not to submit any proposals for financial support until the RFP has been issued.

**1.2** Many organisations from governments, to commercial companies, aid donors, and non-governmental organisations have devoted many years and much money to harnessing energy from biomass to encourage 'development' and the improvement of the welfare of humanity. In the context of this long and varied history, it is important that the Shell Foundation, as a relative new-comer to this field, considers how it can best utilise its 'comparative advantage' to build on this huge effort and add significant value to the process.

**1.3** As a first step in this process the Foundation has decided to concentrate on supporting those biomass-related activities that reduce poverty, or to use the current phrase, that secure the livelihoods of those people in developing countries who do not currently have access to improved energy services[1]. Furthermore it believes that its interventions via support for projects are most likely to produce truly sustainable solutions if the projects and activities it supports are carried out in a business-like manner and aspire to be financially self-sustaining.
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**1.4** But beyond this, Shell Foundation would like to hear your advice as to how to proceed. Many questions spring to mind:

*1.4.1* Are some biomass conversion technologies more likely to be financially self-sustaining than others and yet still produce a substantial poverty benefit? For instance, is it better to focus on 'gasification' rather than the production of methane through fermentation, or some other technology?

[1] While it is fully accepted that there may well be biomass activities that have a substantial effect on environmental issues at both the local and global levels, this is not the primary focus for funding under this theme of the Shell Foundation's 'access programme'.

*1.4.2* Where is the optimal point to intervene in the biomass fuel chain? If the financial viability of biomass conversion technology depends on finding a cash generating end-use for the energy, is this the place to focus attention?

*1.4.3* Are the main constraints to widespread diffusion of modern biomass options related to inadequacies in "enabling environment" rather than inadequacies in the conversion and end-use technologies?

*1.4.4* Would there be more poverty benefits by concentrating on the income generating possibilities of biomass fuel production and preparation than on conversion and end-use?

*1.4.5* Would the Shell Foundation be best advised to leave to others the near to market applications and 'leap frog' technologies by concentrating on gasification and reforming technologies to produce di-methyl-ether (DME) which has essentially the same properties as LPG (liquid petroleum gases), or even proceed directly to the hydrogen economy?

*1.4.6* Are the possibilities of success greater in some countries than others? Where is the 'enabling policy environment' most favourable to poverty reduction through the greater use of modern biomass?

*1.4.7* What types of co-ordination and capacity building activities are required to create the necessary enabling environment?

# 2 Biomass Energy and Poverty

**2.1** According to Professor David Hall, a pioneer in the understanding of biomass fuels,

> *"Bio-fuel in the form of wood, crop residues, brush and animal dung is today still the chief form of [inanimate] energy for the majority of humanity, just as it has been since the discovery of fire".*

The majority of biomass is used in combustion to produce heat for domestic use in cooking (daily living), in industry to provide heat to drive mills via steam turbines, and to dry products, as well as in combined heat and power to provide electricity. Other uses are as charcoal or ethanol motor fuel, however these represent less than 5% of total biomass usage today.

**2.2** But the ways in which this biomass is traditionally produced and used is often "inefficient" (in the technical sense that a great deal of the energy contained in the biomass is wasted), hazardous to the health of women and children, and damaging to the wider environment. However its great virtue is that biomass as fuelwood, straw and stalks and dried dung is an indigenous resource that is often available at low or zero direct monetary cost to the users and can be used in inexpensive equipment.

**2.3** Biomass, of all of the renewable resources, also has the unique characteristic that it stores solar energy until the time of use, and as a result is a resource that can be despatched at will. However, the net storage efficiency on the basis of the input solar energy is rarely more than 2% and often less than 1%, making it a relatively diffuse resource. The International Energy Agency has undertaken extensive studies to properly determine the amount of biomass in the world total primary energy supply (TPES). As much of the biomass does not enter the formal economy, and is not properly measured. Therefore estimates of availability are based on survey activity. Using these techniques the IEA estimates that biomass represents 14% of Total Primary Energy Consumption in the world. In SE Asia consumption rates run at a Primary Energy Supply of 6 GJ/y per person, which is equivalent to 4 - 5 kWh thermal per day per person.

**2.4** However, the 'traditional' use of biomass fuels is frequently inconvenient, inefficient, and, on occasion, damaging to both to the environment and to human health. But it does not need to be so. With the addition of capital, and other resources such as skills and knowledge, biomass can be used to efficiently, cleanly and conveniently. These options are conventionally known as "*modern biomass energy*".

**2.5** In addition to better ways of growing, and harvesting biomass fuels, there are a number of ways of converting biomass fuels to energy, in ways that are more efficient, and more convenient. These include:

- More efficient combustion: (stoves, furnaces, boilers, combined heat and power)
- Pre-treatment of the biomass fuel (densification, chipping, pelletisation,)
- Conversion of solids to liquid fuels (e.g. pyrolysis to a bio-crude oil, fermentation to ethanol))
- Extraction of liquids from solids (plant oil substitutes for diesel)
- Conversion of solids to fuel gases: in the case of wet solids by means of anaerobic digestion[2], and for dry materials such as straw and wood via thermal gasification using air to manufacture a "producer gas" containing carbon monoxide and hydrogen or to a "syngas" that does not contain nitrogen and has a high heating value.
- Conversion of gases to liquids such as the catalytic production of methanol from syngas (hydrogen and carbon monoxide) or the manufacture of synthetic petroleum fractions using Fischer Tropsch catalysts.

**2.6** In some senses modern biomass fuel options have two forms: those that improve or modernise the "traditional" end uses of cooking, and traditional small scale activities such as burning bricks or making sugar (gur); and those that expand end-uses through more modern biomass fuels, particularly through the conversion to electricity. The Shell Foundation will consider the traditional uses of the biomass for cooking through a separate theme on *Household Energy: Breaking the link between traditional patterns of household energy use and poor health in women and children*

**2.7** In the area of modern biomass fuel systems, currently available conversion technology ranges from a solid fuel fired steam boiler and steam turbine for Combined Heat and Power (CHP) at the 500 kW to multi-MWe scale, to gasification of dry biomass (straws, stalks, wood, charcoal) to a low calorific value (LCV) gas for use in either spark ignition (SI) internal

[2] Hydro-Thermal Upgrading (HTU) is a more recent option which "converts biomass at high pressure and at moderate temperatures in water to bio-crude. Bio-crude contains far less oxygen than bio-oil produced through pyrolisis" The World Energy Assessment, UNDP, 2000. However such a process requires a large scale chemical plant calling on serious levels of technical training and capacity building.

combustion engines (ICE) or diesel pilot ICE. Emerging, near-term, technologies include both solid fuelled and direct coupled LCV gasifier combustors to Stirling engines at a small (kW) scale. Anaerobic digestion, while not as universal as solid fuel combustion and gasification, is needed to deal with waste disposal aspects of Concentrated Animal Feeding Operations (CAFO) or a component of a water treatment chain in the provision of clean water. Community/small industry scale 'biogas' units are available today and are easily replicable. The clean up and processing of the biogas (60:40 $CH_4$:$CO_2$ with minor amounts of ammonia and $H_2S$) are proven and pipeline distribution to individual households for cooking, and lighting have long been used in China.

**2.8** Use of the same biogas from Landfills (LFG) to produce electricity is practiced in many countries in both Spark Ignition Internal Combustion Engines and, after compression, in gas turbines. An emerging option of interest is a micro-turbine based Combined Heat and Power system. If the gas is compressed, it can also be used in adapted vehicles as a transportation fuel. Future concepts are also being discussed as a way of modernizing biomass. For instance the replacement of the prime mover (SI, diesel - ICE, steam turbine, gas turbine) by a fuel cell is already demonstrated for Land Fill Gas.

**2.9** But for many of these 'commercial' systems it can be predicted that the installed capacity in the poorer parts of the work is likely to consist of very large numbers of generators at less than 1MW and more likely to be 50 kW, with the potential for 300,000 units of this size in India alone. This conclusion is based on the likely characteristics of demand within de-centralised energy markets (eg at the village level, and excluding the much larger scale sugar industry).

**2.10** The existence of large potential markets and similar generation unit sizes suggests to some people that a modular approach is likely to be required with a relatively small number of size options that are factory manufactured and delivered as packages to locally prepared sites. These packages would include not only the modern biomass to electricity package, but also the components and controls for the mini-grid in which they will serve.

**2.11** A relatively small sub-set of these conversion technologies can be configured in ways that meet the needs of, and have a direct impact upon, marginalized people in developing countries, in terms of cost, scale and sophistication. However, it is likely that a wider range of systems can have important *indirect* poverty impacts by providing the energy to productive-end uses that employ people and generate incomes, and in the processes that grow and harvest biomass fuels.

**2.12** In addition to arguments about energy efficiency the most important reasons to modernise biomass fuels is to address the adverse Health, Environment and Safety impacts of current biomass practice. These include the impacts on indoor air quality, or the loss of nutrient from the use of dung, or the human cost of gathering biomass resources. Such improvements can be achieved either by stopping the use of biomass, or by significantly improving the efficiency of use, thus reducing actual fuel/feedstock input per unit of delivered service, and reducing the excessive burden of products of incomplete combustion (PIC) that characterize almost all combustion applications of biomass at both household and industrial levels in developing countries.

**2.13** The technological means to address this are in fact already to hand, larger scale combustors do not have be of low efficiency and nor do there have to be high emissions of particulates and PIC. Though so-called improved stoves have made only minor improvements so far, there are solutions even to the small scale cook-stoves that make quantum improvements in both emissions and efficiency, ranging from forced air cook stoves, to household distribution of biogas and producer gas, and the use of prepared fuels such as fuel pellets or charcoal in appropriately designed combustors for domestic and business/commercial use.

# 3 Constraints and their removal

**3.1** *Institutional constraints*. Since 1970 there have been many successful technical developments in biomass conversion, but the demonstration of many of them have been deemed to be failures as they have not achieved all of their social or economic goals. However such a verdict may well be premature. In future a more effective combination of the technical successes with adequate preparation at the institutional level is required. These range from the removal of regulations that prohibit the sale of electricity by any organisation other than the national utility; to the provision of the many forms of 'intermediation' required to bring schemes to sustainability. But just as important can be the less obvious barriers to the diffusion of modern biomass as politically motivated promises that grid line extension or the promise of low cost electricity for large scale farmers

**3.2** More effective development of the necessary institutional infrastructure could lead to near term replicable "pilot pathways" which could be used as the basis for a rapid deployment of modernized biomass. The idea of "pathways" is attractive as there is clearly no one single cause for non-attainment of sustainable biomass energy development as it necessitates dealing with a multiplicity of parameters at several geographical scales, and multiple levels of government. It is also clear that it is likely to require strong coordination and extensive capacity building in developing countries to be effective.

**3.3** Any modern biomass system consists of a minimum of four steps in a chain from resource to end use, comprising **r**esource production, **t**ransportation and **l**ogistics and **c**onversion to useful energy which is **d**istributed to consumers. For brevity this chain is described as the *RT&LCD* system.

**3.4** *The Biomass Fuel System.* Most attention has been focused on the conversion technology and relatively little effort has been expended on distribution issues. The distribution aspect is presumed to be covered in the near term technologies by either electricity distribution or gas storage and pipelines, However, in the case of electricity there would still appear to be an urgent need for "simplified" and economical, but safe mini-grid standardized distribution systems without compromising either reliability or consumer safety.

**3.5** At the up stream end of the system biomass fuels need to be made available in sufficient volume and quality to meet the demand. This requires the establishment of a supply and logistics chain that will accommodate seasonal constraints (wet, dry), and provide storage for periods sufficient to cover supply interruptions and peak demands. Generally this has to be achieved at a feedstock price that is a significant fraction of the price of fossil fuels on an energy equivalent basis - typically a ratio of less than 50%. Furthermore it will be important that the supply of biomass fuels does not adversely affect existing (non-fuel) demand for both biomass and land. This is sometimes described as the *food-fuel problem*.

**3.6** *Fuel Preparation.* One upstream option that would "modernize" the use of biomass energy would be the use of pelletising technology to provide both a uniform fuel (which would standardize and reduce the cost of the in-feed component of the conversion technology) and reduce the transportation costs due to its 3x energy density. A pelletising operation would allow better regional distribution and, by blending, would produce superior final biomass fuel qualities in a region with diverse biomass resources, as well as standardizing conversion technologies. However the energy required for fuel compaction and transport can itself form a considerable cost barrier to wider application. Similarly it may well remain more profitable (though less physically efficient) to produce charcoal with next to no capital equipment (eg using earth mounds or clamps) than to invest in palletising equipment and the energy to operate it.

**3.7** *The Scale of Development.* The resource production and transportation area is presently dominated by either traditional and, or informal structures. Today it is the household which handles the entire *RT&LCD* chain, but the near term it is likely that successful solutions will require the *RT&LCD* chain to be managed on the scale of a whole village. But within a decade it is likely that the scale on which biomass is modernized will need to be at a regional level that encompasses many villages and integrates and manages the whole biomass potential.

**3.8** *Cost.* There are a number of promising routes to reducing the cost of biomass conversion technologies. In manufacturing the plants to date most units have been built in very small batches and have therefore not benefited from the economies of scale of mass production, nor in the application of production engineering concepts to improve the manufacture of the units. Furthermore in-field installation and start-up involve large and unpredictable costs . It is only with some form of modularisation and the delivery of packages to a pre-prepared site that costs can be controlled and lowered. In fact given the needed scale of implementation of 100's of thousands of units per year this is the only practical route to follow. This adds even more weight to the need for improved fuel preparation, as many projects have failed in the past because of insufficient fuel preparation both with respect to size distribution and moisture content.

**3.9** *End-Use Demand.* For a given demand, the nature of load curve, a plot of the energy demand versus time (hour, day, week, month, year) dictates the size of the equipment to be purchased and the performance required. Frequently the load- duration curve reveals peaks in demand that would be better served by a supplementary source. Equally, large diurnal load changes such as are experienced by village power systems would probably require a number of energy sources as the ability of any given technology to respond to load variation (in engineering terms: the turn-up turn-down ratio) is restricted to a narrow range often from full power to no more than 50 - 60% of full power. Existing isolated mini grids, usually show a number of different sizes of diesel gen-sets which are operated in parallel to respond to load variation.

**3.10** *Load Factors.* After the application of the demand time curve, it is very important that the average utilization is spread over a significant fraction of the year. Typically technologies for biomass energy - boiler, engine, gasifier, digester – usually result in investments of at a minimum of 300 $/kW thermal, and for power systems the figure is more likely to be at least 1000 $/kWe. In addition there are recurrent operating costs and maintenance that if not provided will result in very low availability of equipment - this was in fact a major part of the reason for lack of success with many biomass systems. Both capital repayment and the organization for O&M are fixed costs, and it is likely that these costs will have to be spread over at least 1500 hours of operation (17% of the possible hours) if these costs are to represent a reasonable proportion of the final cost of electricity. In any case at the current stage of biomass conversion technology is likely to achieve levels of availability that are less than a diesel fuelled generating set, and therefore may require a redundant back up system.

**3.11** *Cash-generating Loads.* It is a truism to say that modern biomass energy systems are likely to be more financially viable if the electricity generated can be used to supply power to a profitable cash-generating enterprise. The use of a single mill or pump for a few hours per day can clearly raise plant load factors substantially. However, studies show that such energy using enterprises are often difficult to develop. Combining new energy conversion installations with new income generating enterprises that have a daytime use for the energy in remote locations presents a formidable challenge to investors, managers and project promoters, not least because local markets are often small and isolated. However it appears some project promoters have achieved this difficult task[3].

**3.12** *Poverty Impact of Energy End Uses.* As people do not want energy for itself, but for what it will help them to do, the poverty impact of improvements in biomass energy services will be largely determined by the choice of end-use to which the energy is put, and by implication, by who chooses what the energy will be used for (and how it is obtained). Even though this appears so self evident as to be trivial, it is surprising how little attention is given by analysts and policy makers to these choices. If energy services are allocated to tasks that are traditionally considered in the woman's domain, for instance, or to new activities not yet dominated by men, it can have a considerable (targeted) impact on women's lives.

**3.13** *The Availability Of Human Capital.* While poverty may well be associated with lack of access to improved energy services, it is increasingly recognised that the shortage is less to do with lack of energy and more to do with the lack of human and physical capital required to convert the primary energy and to use it effectively. The human capital trained to operate modern biomass systems appear to be radically different to the fossil equivalent and introduce different Health, Environment and Safety (HES) skills.

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[3] It is hoped that the firms responsible for these plant in India will confirm these data and share their experience in the electronic dialogue.

**3.14** *To Subsidise Or Not To Subsidise?* Markets in which customers have sufficient income to cover all costs (capital, fuel, O&M, capital replacement) can probably be served by a structure such as a Rural Energy Service Company (RESCO). But for poorer people, when only limited payment is possible, a wise subsidy may be required to ensure that the services are delivered and that the communities can start to improve economically. In the middle income group, probably all costs other than initial capital investment can be covered, but innovative financing and support infrastructure is likely to be required.

**3.15** *Other barriers*: A lack of information about the potential biomass supply is frequently cited as a barrier to development of this sector, and current resource estimates are thought to be less complete than those in other renewable energy sectors. Again some pre-packaged approach to resource estimation and development may well be needed, preferably based on dynamic geographic information system (GIS) data bases.

**3.16** *Lack of Financing* has also been frequently cited as a major reason for little or no progress in the commercial diffusion of biomass energy resources. But here the evidence is often unclear. There may be commercial money available, but the lenders have no experience of investing in these "novel" (to them) technologies and therefore see them rightly or wrongly as high risk. Similarly the lack may not be for loan capital, but rather equity or softer capital that can cover the risk and the high transaction costs of small 'one-off' investments.

Other THEMES

--Choose--

# Modern Energy Services

Stimulating Innovation in the Delivery of Energy Services to Poor Communities

## Modern Energy Services - The story so far.


The direction of SEP's Modern Energy Services theme has emerged from a dialogue process that took place during 2001. The outcome helped to produce a strategy for the Energy Services theme and determine the context of the Request for Proposals issued by the Shell Foundation on 27th February 2002.

"*Although initially the modern biomass and energy services themes were treated separately, the dialogues demonstrated that the unifying factor in addressing both issues was how to provide such services in a financially viable or business like manner. SEP will therefore include modern biomass under the energy services theme. Work on this theme will focus upon areas of consensus that emerged from the dialogue process under both energy services and modern biomass*"

The dialogue process took place in three phases:

**Phase one: Background papers**
Commissioned background papers identified key issues and provided the background and context for each electronic dialogue. In addition, they also provided empirical rationale for the Foundation's focus on each theme. Each background paper including an additional paper by Sivan Kartha and Gerald Leach (Stockholm Environment Institute) are available below.

- Energy Services: Innovating to deliver modern energy services to poor communities in developing countries – Andrew Barnett - April 27th 2001
- Modern Biomass: Modernization of Biomass for Poverty Reduction - Ralph Overend and Andrew Barnett - April 12th 2001
- Using modern bioenergy to reduce rural poverty - Sivan Kartha and Gerald Leach (Stockholm Environment Institute) – August 2001

**Phase two: Electronic Dialogues**
"on-line," moderated debates (4-5 weeks) took place for each theme between registered participants via the Shell Foundation website. In total, more than 150 expert participants took part in these debates based on the background papers above, the debates generated very useful comment and insight. Each week participants addressed four specific questions and contributions were summarised each week and sent to participants along with the next question. A summary of each dialogue can be downloaded below.

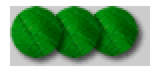
Energy Services: Dialogue 16th May– 15th June – *Moderated by Andrew Barnett*
Modern Biomass: Dialogue 16th April – 20th May – *Moderated by Ralph P. Overend*

**Phase three: Stakeholder workshops**



Other ITEMS

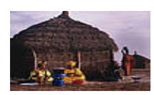
Modern Energy Services
**- What Is Biomass? -**



Biomass is an agricultural bio-product, be it a maize stalk, a coconut husk, a piece of charcoal, weeds, or cattle dung..

More

Modern Energy Services
**- The story so far.**



The direction of SEP's Modern Energy Services theme has emerged from a dialogue process that took place during 2001.

More

The thematic dialogue process culminated in two, one-day workshops for the Energy Services and Modern Biomass themes. Each workshop had 25 to 30 participants from various countries and institutions. A short report of each workshop is available below.

- Energy Services - Workshop in London 25th July – Read the report
- Modern Biomass - Workshop in London 30th May – Read the Report

**Request for Proposals**
As a result of the background papers, on-line dialogues and workshops, the Shell Foundation has developed its Sustainable Energy Programme (SEP) strategy. One aim of the SEP strategy is to support exemplary projects that contribute to the "Increasing Access" objective, which is to increase the access of low-income communities and households in developing countries to modern energy services – Request for Proposals were issued on March 27, 2002.

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